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(54) Function indicator for visually indicating an operating state of equipment

(57) A function indicator for visually indicating an operating state of equipment comprises at least one light emitting element 4, and an optically transparent member OB for distributing the light emitted by the light emitting element 4. The optically transparent member has a light distribution portion BS with a first recess 7 and a second recess 8 opposite to the first recess 7. The light emitting element 4 is arranged proximate to one (7) of the two recesses such that the vertices of the two recesses are located essentially on the light emission main axis of the light emitting element 4. The opening angles φ_1, φ_2 of the two recesses 7, 8 are such that light rays emitted from the light emitting element 4 are refracted by the surface of recess 7 to be incident on the surface of the recess 8 at an angle $\Theta 3$ of total reflection, to be thereby reflected into the light distribution portion BS of the optically transparent member.

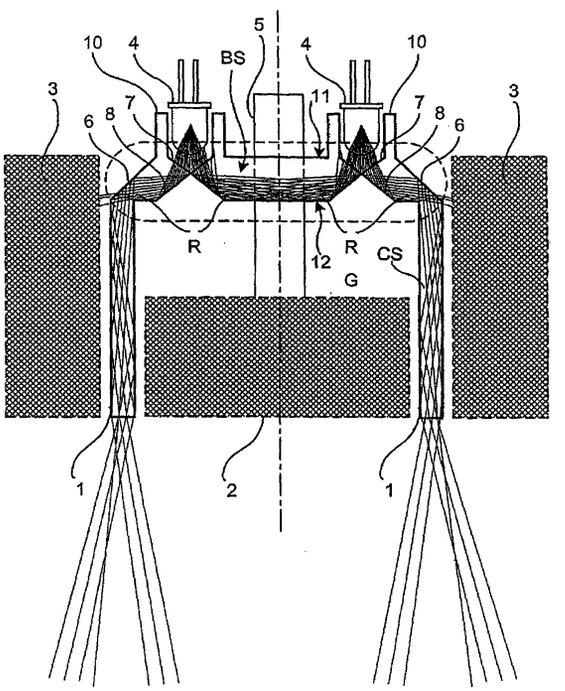

Fig 2

EP 1 389 788 A1

Description

[0001] The present invention relates to a function indicator for visually indicating an operating state of equipment.

[0002] There exists a variety of function indicators, used e.g. in consumer electronic devices or industrial equipment, for visually indicating the status, activation or deactivation etc. of electrical or electronic functions of the device or equipment to a human operator. Function indicators of this kind can have the form of an illuminated ring around a push button of a switch, examples of which can be found in elevator control panel applications, front panels of television sets and the like.

[0003] Light emitting diodes (LED) are a suitable means for illuminating a function indicator of this kind. Light emitting diodes typically emit a majority of the generated light from the front, due to the provision of an embedded convex lens which collects the light rays generated by the semiconductor chip of the LED. This lens provides for the emission of the light rays in directions diverging by a specified angle from a light emission main axis of the light emitting diode.

[0004] US 5,391,848 discloses a function indicator in the form of an illuminated light ring around a push-button switch, the light ring being illuminated by a plurality of light emitting diodes. The structure disclosed in this document comprises at least 3 optical elements and 5 light emitting diodes in order to achieve a satisfactory visual appearance of the function indicator to the human operator. In this document, the push button is transparent. A light reflector is provided for guiding light generated by the light emitting diodes to the push button, the light reflector including a reflector portion and a base portion. A plurality of axially extending apertures are formed in the light reflector for guiding light generated by associated ones of the light emitting diodes to the push button.

[0005] US 5,039,832 discloses an illuminated touch button system having a light ring element as well as a button element located within and surrounded by the light ring element, as well as an array of light emitting diodes. The light ring element proposed in this document comprises a series of individual chambers, each chamber including a set of three light-receiving triangulated surfaces. These surfaces have a series of edges which act to diffuse the illumination of the light emitting diodes. These edges in combination with the chambers, are provided to produce a relatively even, bright light distribution in the portion of the light ring element surrounding the button element.

[0006] The optical function indicators known from these prior art documents suffer from the disadvantage, that a considerable number of light emitting diodes is required to achieve a visual indication which can be considered satisfactory for a human operator. In US 5,391,848 a large number of light emitting diodes is required to achieve a sufficient minimum brightness level over the entire surface of the transparent push button. In US 5,039,832 a comparatively large number of light emitting diodes is necessary in order to achieve a uniform brightness distribution of the light ring around the touch button. In this known structure, the provision of a ring of LEDs is mandatory to achieve this, since the known structure is unable to distribute the light generated by a single LED in a well balanced manner over the entire light ring. This leads to an increased power consumption for illuminating the known function indicators.

[0007] Accordingly, it is the object of the present invention, to provide a function indicator for visually indicating an operating state of equipment, which function indicator has an increased light coupling efficiency and offers an improved light distribution of the light coupled into the function indicator across a visibly arranged indicator surface of the function indicator.

[0008] According to the present invention, this object is solved as defined in claim 1. Advantageous embodiments of the present invention are defined in the dependent claims.

[0009] According to an embodiment of the present invention, the function indicator comprises an optically transparent member which has a light distribution portion for distributing light received from at least one light emitting element to propagate between a first and a second main surface of the light distribution portion of the optically transparent member, which first and second main surfaces define a light distribution plane of the optically transparent member. In order to efficiently couple light emitted by the light emitting element in directions diverging from a light emission main axis of the light emitting element, into the optically transparent member to propagate in lateral directions, recesses are provided opposite to each other on both the first and the second main surfaces of the light distribution portion. At least portions of these recesses have a crater shape, these craters preferably being in the form of rotationally symmetrical funnels. The light emitting element is arranged close to one of the two recesses, such that the vertices of the two opposing recesses are located essentially on the light emission main axis of the light emitting element. The opening angles of the first and second recesses are selected such that light rays emitted from the light emitting element are refracted by the surface of the first recess proximate to the light emitting element. These refracted light rays then travel in the optically transparent member at an increased divergency angle, compared with the divergence of the light rays incident on the first recess, to be then incident on the surface of the second recess at an angle of total reflection. The opening angles of the two recesses are such, that by means of the refraction and total reflection, the emitted light rays are directed into the light distribution portion, to travel generally in a lateral direction in the light distribution plane toward the periphery of the light distribution portion of the optically transparent member.

[0010] With this structure, light emitted by the light

emitting element at a specified angle of divergence can be coupled efficiently into the light distribution element for well balanced lateral distribution toward the periphery of the light distribution portion.

[0011] According to a particular embodiment of the present invention, a periphery of the light distribution portion acts as an indicator portion with an indicator surface which is visible by a human operator. This arrangement is advantageous, e.g. if an omni-directional visibility of the function indicator is desired.

[0012] According to another embodiment, an indicator portion is coupled to the periphery of the light distribution portion such that the indicator portion extends generally perpendicularly from the light distribution plane. The indicator portion can be optically coupled to the light distribution portion by means of an inclined surface at the periphery of the light distribution portion of the optically transparent member, the inclination angle being selected such that the light rays travelling in a direction of the light distribution plane, are coupled into the indicator portion by means of total reflection.

[0013] The vertices of the first and second recesses can be arranged to be abutting, or some space can be left between the two vertices of the recesses. The recesses preferably have a funnel shape, i.e. a rotational symmetry, to match with the rotational symmetry of the light ray pattern emitted by a light emitting element with circular cross section around the light emission main axis. If light emitting elements with rectangular, triangular or any other cross section are used, the shape of the crater is preferably adapted to match with the particular radiation pattern achieved by the particular light emitting element.

[0014] Preferably, the light emitting element is mounted in and a hollow, generally cylindrical member protruding from the main surface of the light distribution portion which is proximate to the light emitting element, this hollow protrusion having an inner diameter and cross section shape suitable for fitting the light emitting element. Preferably, the hollow member, the light distribution portion and the indicator portion are formed integral as a single moulded optically transparent member.

[0015] Preferably, the light indicator portion has a hollow, generally cylindrical shape, the term "cylindrical" not being limited to circular cross sections, but also including rectangular or polygonal cross sections. This hollow, generally cylindrical shape can be provided to accommodate a push button as well as a switch operated by a push button. In this arrangement, small diameter through holes can be provided in the light distribution portion or in the light indicator portion for wires making an electrical connection of the switch arrangement with external circuitry.

[0016] Other preferred arrangements include the provision of a through hole in the light distribution portion of the optically transparent member for receiving a shaft which connects the push button member located within the hollow cylindrical light indicator portion, to the switch arrangement arranged on the other side, i.e. behind the light distribution portion of the optically transparent member. If the diameter of the through hole is kept sufficiently small, and/or if the shaft connecting the push button with the switch arrangement through the light distribution portion is made from optically transparent material, preferably with the same refractive index as the material of the light distribution portion, the through hole will not cause any significant disturbance of the light distribution in the light distribution portion of the optically transparent member. Alternative arrangements include the provision of more than one through hole to mechanically couple the push button with the switch arrangement through the light distribution portion.

[0017] While the provision of a single light emitting element can be generally sufficient to satisfactorily illuminate the indicator surface of the optically transparent member, more than one light emitting elements can be provided and preferably equally distributed across the light distribution portion of the optically transparent member, each light emitting element being associated with a pair of recesses opposite to each other as described above.

[0018] Preferably, the optically transparent member is made of poly carbonate, silicon dioxide, glass or any other transparent organic or inorganic rigid or flexible material with a refractive index larger than one. Depending on the desired optical appearance, the optically transparent member can be coloured or uncoloured. It can be clear or it can be diffused or light opaque. If more than one light emitting element is provided, these light emitting elements can have different light colours such that different operational states can be distinguished by the different colours.

[0019] In the following, a preferred embodiment of the present invention will be described in detail with reference to the accompanying drawings. Throughout the figures, corresponding or identical elements are denoted with the same reference characters.

Fig. 1 shows a typical external view of a push button switch with a light ring.

Fig. 2 shows a cross section along a direction A-A' in Fig. 1 of the push button switch with a light ring in accordance with the present invention; and

Fig. 3 shows a detailed view of a portion of the cross section diagram shown in Fig. 2.

[0020] Fig. 1 shows a typical front view of a television set having a push button switch 2 surrounded by a light ring 1. Depending on the operating state of the television set, i.e. off, standby or on, the light ring 1 appears dark to a human operator, or illuminated, for example red when the television set is in standby mode, and green if the television set is on. The visible light ring is essentially constituted by an indicator surface 1 of an optically

transparent member which indicator surface, when illuminated from behind, appears as the light ring around the push button 2. In this embodiment the light ring and the push button 2 are provided essentially flush with each other, that is the push button 2 is located essentially in a plane defined by the indicator surface 1 of the light ring 1.

[0021] Reference numeral 3 denotes a casing of a television set accommodating the push button 2 surrounded by the light ring 1. G denotes a gap between the push button 2 and the light ring 1 in order to allow a stroke movement of the push botton when actuating the switch.

[0022] Fig. 2 shows a cross section of the structure shown in Fig. 1 along the line A-A' in Fig. 1. As shown in Fig. 2, light rays R emitted from LED devices 4 are coupled into an optically transparent member OB in order to guide the emitted light rays R towards the indicator surface 1 which is arranged at the front of the TV set to be visible by an operator of the push button 2. The indicator surface 1 constitutes an exit for the light rays R leaving the optically transparent member OB.

[0023] The optically transparent member OB shown in Fig. 2 comprises a light distribution portion BS which has a first main surface 11 as well as a second main surface 12 opposite to the first main surface 11. These two surfaces define a light distribution plane. Here, the term light distribution "plane" is not limited to a strictly mathematical meaning but denotes a variety of laterally oriented propagation directions between the first and the second main surfaces 11, 12, as indicated in Fig. 2 by means of the generally horizontal orientation of the light rays R in the light distribution portion BS.

[0024] Reference numeral CS denotes an indicator portion of the optically transparent member OB which has a hollow cylindrical shape and which extends in an essentially perpendicular direction from the second main surface 12 of the light distribution portion BS and which has a circular cross section in this embodiment, as shown in Fig. 1. Reference numeral 10 of Fig. 2 denotes generally cylindrical hollow members protruding from the first main surface 11 of the light distribution portion BS. Each of the hollow members 10 receive a light emitting diode 4, each light emitting diode having a convex lens proximate to the first main surface 11 of the light distribution portion BS. Although not shown in the Fig., it can be advantageous to provide the generally cylindrical hollow member 10 with a triangular, star shaped or square cross section for fitting light emitting elements 4 with a circular cross section. This will reduce the contact surface between the base portion of the light emitting element 4 and the hollow member 10 and hence reduce unwanted lateral light coupling from the base portion of light emitting element 4 into the hollow member 10.

[0025] Reference numeral 7 denotes first recesses provided in the first main surface 11 of the light distribution portion BS, each recess being associated with one of the LEDs 4. Reference numeral 8 denotes second recesses provided in the second main surface 12 of the light distribution portion BS. In the embodiment shown in Fig. 2, each light emitting diode 4 is associated with a first recess 7 proximate to the light emitting diode 4 and with a second recess 8 opposite to the first recess 7. In the embodiment of Fig. 2, the vertices of the first and second recesses associated with a particular light emitting diode 4 are arranged to abut to each other on the light emission main axis of the LED 4.

[0026] Reference numeral 6 denotes an inclined surface at the periphery of the light distribution portion BS. This inclined surface acts as a reflector exploiting the phenomenon of total reflection, for coupling light rays R travelling in the light distribution plane of the light distribution portion BS, into the indicator portion CS in order to leave the indicator portion CS through the light ring 1.

[0027] Reference numeral 5 denotes a shaft mounted to a rear side of the push button 2. The shaft 5 reaches through a hole concentrically arranged in the light distribution portion BS of the optically transparent member OB in order to mechanically connect the push button 2 to a switch arrangement not shown in Fig. 2, which is located outside the hollow space defined by the generally cylindrical hollow indicator portion CS and behind the light distribution portion BS.

[0028] Fig. 3 shows an enlarged view of a portion of the optically transparent member OB. As shown in Fig. 3, the optically transparent member OB according to this embodiment has three stages for deflecting the light rays emitted by the light emitting diodes 4 to reach the indicator surface 1 of the indicator portion CS. The first stage is a conical or funnel shaped surface of the recess 7 which acts to further increase the angle of divergence of the light rays emitted by the LED 4 by means of refraction. In Fig. 3, ϑ_1 denotes the incidence angle of the light rays on the surface of the first recess 7. In order to deflect the refracted light rays R to travel in a lateral direction, i.e. in the light distribution plane of the light distribution portion BS toward the periphery of the light distribution portion, the recess 8 shown in Fig. 3 constitutes an additional conical or funnel shaped surface in the light distribution portion BS opposite the recess 7. This second surface acts to reflect the light rays refracted by the surface of the first recess 7 by means of so-called total internal reflection of the light rays at the conical surface of the recess 8.

[0029] As shown in Fig. 3, the opening angles of the first recess 7 and the second recess 8 are such that the light rays R are refracted by the surface of recess 7 to be incident on the surface of recess 8 at an angle of total reflection, to be thereby reflected into the light distribution plane. According to the embodiment shown, once the majority of the light rays emitted by the LED is coupled into the light distribution portion BS by means of the conical or funnel shaped surfaces of the first and second recesses, a third inclined surface 6 at the periphery of the light distribution portion BS redirects the light rays R to enter into the indicator portion CS best

shown in Fig.2, To this end, the opening angles of the first recess 7 and the second recess 8 as well as the inclination angle of the surface 6 are designed such that the angles Θ2 and Θ3 are less than $Sin^{-1}(n_{air}/n_{OB})$ wherein n_{air} denotes the refractive index of the air and n_{OB} denotes the refractive index of the material used for manufacturing the optically transparent member OB.

[0030] In the embodiment shown, the light distribution portion BS has a generally circular shape and accordingly, in the shown embodiment the inclined surface 6 has a conical shape. As shown in the figures, the light guided by the light distribution portion BS and the indicator portion CS may propagate in the light distribution plane with additional total reflections between the first and the second main surfaces of the light distribution portion BS and between the inner and outer surfaces of the cylindrical indicator portion CS until they reach the indicator surface 1 and leave the optically transparent member OB.

[0031] To preserve the brightness uniformity at different viewing angles of the indicator surface, it can be preferable to provide the indicator surface 1 with a certain surface roughness to scatter the light rays. If the indicator surface 1 is a polished surface, a brighter light ring will be perceived at a reduced viewing angle. In order to increase the viewing angle, a diffuse coating can be applied to the indicator surface 1, or a texture may be provided in the mould used for manufacturing the optically transparent member OB at the area corresponding to the indicator surface 1. In order to achieve optimum light guiding properties of the optically transparent member OB, it is preferable that the other surfaces of the optically transparent member OB are as smooth as possible to obtain an optimal internal total reflection factor.

[0032] The preferred embodiment shown in the Figures is made of transparent polycarbonate material with a refractive index n_{OB} of about 1,59 for the visible spectrum of light. The optically transparent member OB is surrounded by air which has a refractive index n_{air} of approximately 1. This will result in a critical angle Θ_c for this material which can be calculated in accordance with the above formula and amounts to about $Sin^{-1}(1/1,59) = 39°$. The opening angles of the first recess 7 and the second recess 8 in the embodiment shown must therefore be such that Θ_3 and Θ_2 in Fig. 3 are less than 39°.

[0033] One of many possible solutions meeting the afore-mentioned conditions will now be given for the preferred embodiment shown in the figures. The ratio of the base diameter to the height of the first recess 7 can be selected to be 2,54, corresponding to an opening angle of $\varphi_1 = 51,78°$. The base diameter to height ratio for the second recess 8 can be selected to be 3,41, corresponding to an opening angle of $\varphi_2 = 59,6°$. The inclination angle of the conical surface 6 at the periphery of the light distribution portion BS can be selected to be approximately 45° with respect to the light distribution plane defined by the first and second main surfaces 11 and 12 of the light distribution portion BS. All these values apply for a refractive index of 1,59 of the material used for making the optically transparent member OB. If a different material with different retraction index n_{air} is used, the values for φ_1 and φ_2 may have to be suitably adapted.

[0034] The given geometrical definition for the preferred embodiment provides an acceptable range of functionality for a refractive index n_{OB} in the range of 1,45 to 1,75. Accordingly, not only polycarbonate but also other transparent material may be suitable for manufacturing the optically transparent member OB. This flexibility also allows the use of multi colour light emitting diodes as light sources, for example red and green, since similar light rate propagation results will be achieved for each colour that this type of LED is able to emit. The values given for the opening angles φ_1 and φ_2 in the specific example are not the only values for which a sufficient coupling of the light into the light distribution portion BS can be obtained. Opening angles for the recesses 7 and 8 in a range of ± 15% of the values given for φ_1 and φ_2 will achieve a satisfactory result. While in the embodiment described above, the first and second recesses 7 and 8 have been shown to be in a symmetrical relation with the light emission main axis of the LED 4, it would be possible to provide an offset angle between the symmetry axis of one or both of the two recesses 7, 8 and the light emission main axis of the LED. This offset angle would affect the divergence of the light rays propagating in the optical body, and hence the divergence of the light rays leaving the indicator surface 1.

Claims

1. A function indicator for visually indicating an operating state of equipment, said function indicator comprising

   - at least one light emitting element (4) for emitting visible light rays (R) in directions diverging from a light emission main axis of said light emitting element (4); and

   - an optically transparent member (OB) having a light distribution portion (BS) having a first (11) and a second (12) main surface which define a light distribution plane therebetween, and at least one indicator portion (CS) optically coupled to a periphery of said light distribution portion, said indicator portion having an indicator surface (1) to be arranged visible for said operator;

   - a first recess (7) provided in said first main surface (11) of said optically transparent member (OB), and a second recess (8) provided in said second main surface (12) of said optically

transparent member (OB) opposite to said first recess;

- at least portions of each of said first and second recesses having a crater shape, each crater defining a vertex and an opening angle (φ_1 φ_2);

- said light emitting element (4) being arranged proximate to one (7) of the two recesses (7, 8) such that the vertices of said recesses are located essentially on the light emission main axis of said light emitting element (4);

- wherein the opening angles (φ_1, φ_2) of said first (7) and second (8) recesses are such that light rays (R) emitted from said light emitting element (4) are refracted by the surface of said first recess (7) to be incident on the surface of said second recess (8) at an angle (Θ3) of total reflection, to be thereby reflected into the light distribution portion (BS) to propagate between said first and second main surfaces (11, 12) along the light distribution plane.

2. The function indicator according to claim 2, wherein the vertices said first (7) and second (8) recesses abut to each other.

3. The function indicator according to claim 1 or 2, wherein said crater shaped first (7) and second (8) recesses have a rotationally symmetrical shape.

4. The function indicator according to any one of the preceding claims, comprising a hollow member (10) protruding from the first main surface (11) of said light distribution portion along the periphery of said first recess (7) to accommodate said light emitting element (4) in alignment with said first (7) and second (8) recesses.

5. The function indicator according to any one of the preceding claims, wherein said indicator portion (CS) is formed integral with said light distribution portion (BS) and extends from the periphery of said light distribution portion (BS) in a direction perpendicular to said light distribution plane.

6. The function indicator according to claim 5, wherein a reflecting surface (6) is provided at the periphery of said light distribution portion (BS), said reflecting surface (6) being inclined relative to said light distribution plane such that light travelling in said light distribution portion (BS) is optically coupled into said light indictor portion (CS) by means of total reflection.

7. The function indicator according to any one of the preceding claims, wherein said light indicator portion (CS) has a hollow, generally cylindrical shape with a circular, rectangular or polygonal cross section.

8. The function indicator according to claim 7, comprising a push button (2) operated switch arrangement having a user operable push button (2) which is concentrical with said cylindrical indicator portion (CS), an external surface of said push button (2) being generally flush with a plane defined by said indicator surface (1) of said indicator portion (CS).

9. The function indicator according to claim 8, wherein one or more light emitting elements (4) are provided in an arrangement which is symmetrical with respect to a central location of said light distribution portion (BS) of said optically transparent member (OB).

10. The function indicator according to claim 9, wherein said push button (2) as well as said switch arrangement is accommodated within said hollow light indicator portion (CS).

11. The function indicator according to claim 10, wherein said light indicator portion (CS) extends from said second main surface (12) of said light distribution portion (BS) of said optically transparent member (OB).

12. The function indicator according to claim 10 or 11, wherein through holes are provided in said light distribution portion (BS) or in said light indicator portion (CS), for making an electrical connection of said push button (2) switch arrangement with external circuitry.

13. The function indicator according to claim 8 or 9, wherein said switch arrangement is provided outside said cylindrical indicator portion, at least one through hole is provided in said light distribution portion (BS), and at least one shaft is provided for mechanically connecting said push button to said switch arrangement through said at least one hole.

14. The function indicator according to any one of the preceding claims, wherein said light emitting element (4) is a light emitting diode which comprises a convex lens for emitting the generated light rays with a specified divergence from its light emission main axis.

15. The function indicator according to any one of the preceding claims, wherein said optically transparent member(OB) is made of polycarbonate.

16. The function indicator according to any one of the preceding claims, wherein said light emitting ele-

ment (4) is mounted to illuminate said optically transparent member (OB) such that said light emission main axis of said light emitting element is generally perpendicular to said light distribution plane.

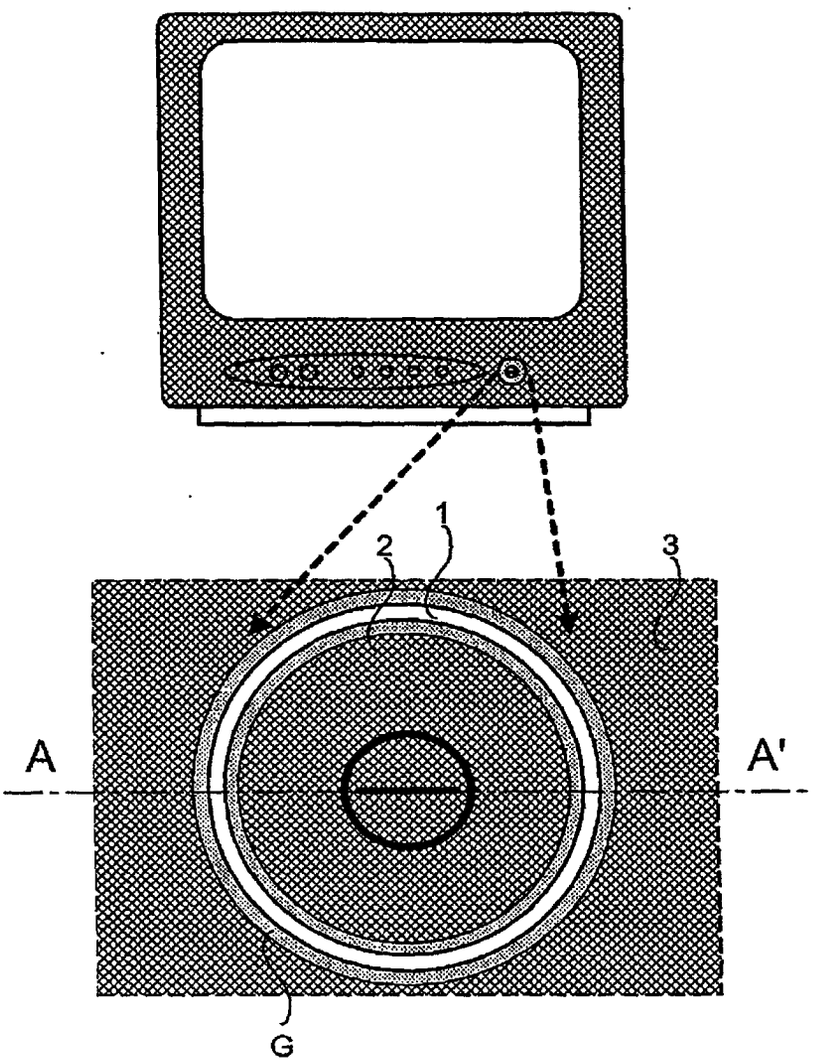

Fig 1

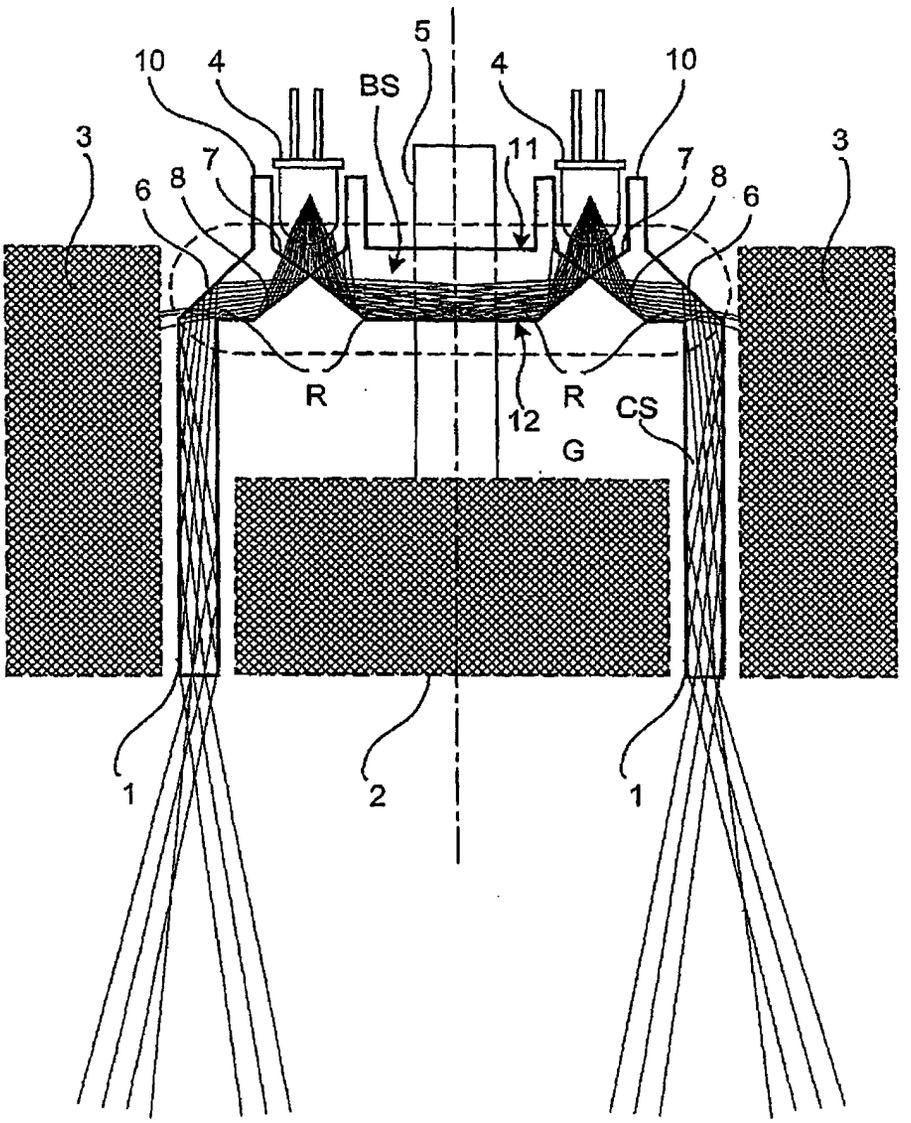

Fig 2

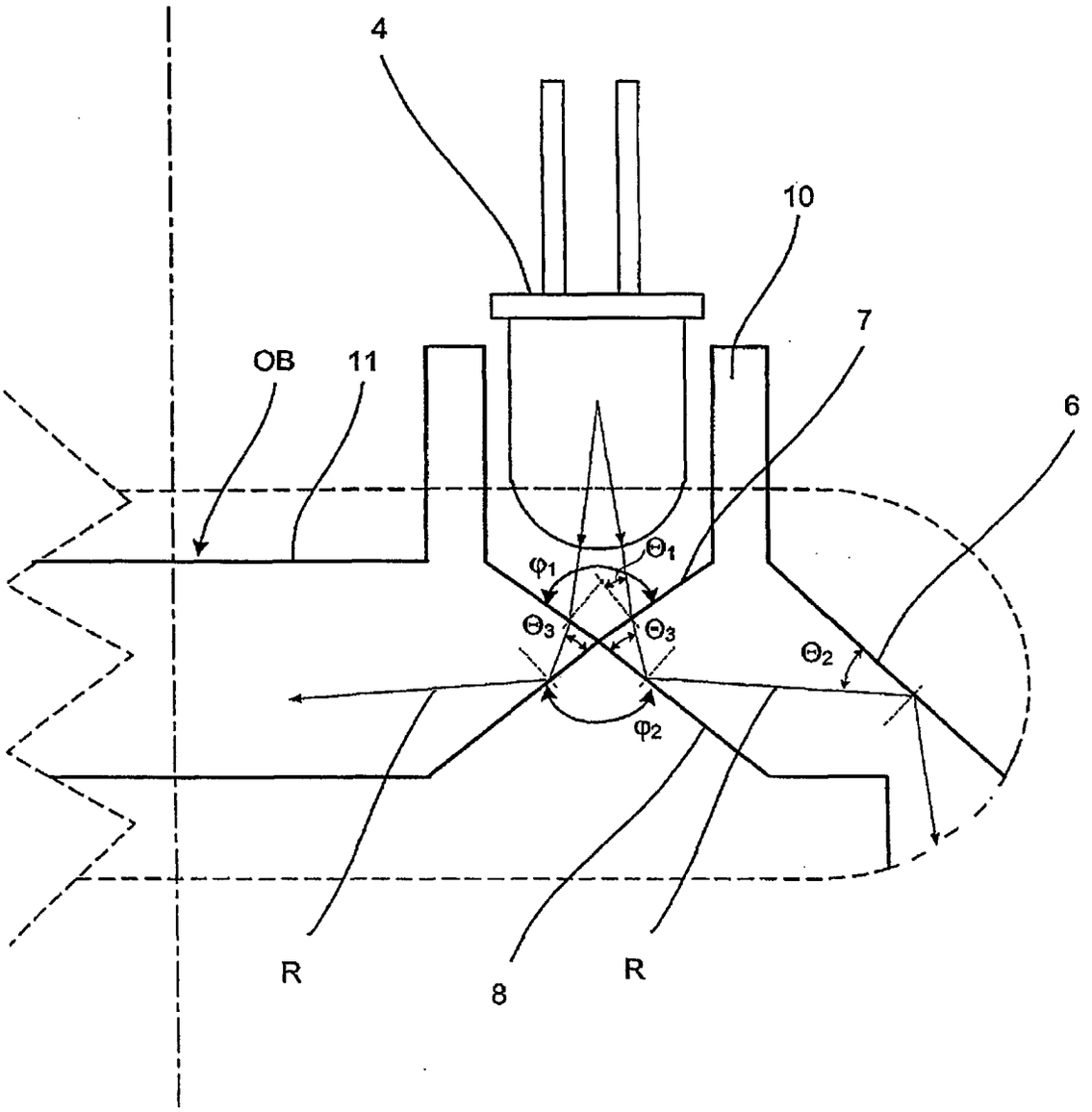

Fig 3

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 October 2002	Ramírez Fueyo, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

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THE HAGUE	4 October 2002	Ramírez Fueyo, M

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